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RESEARCH PAPER

Effectiveness of World Wide Fund advisory services for integrated pest and disease management in sugarcane farming in Jhang, Pakistan

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Abstract

Sugarcane is a vital cash crop in Pakistan, yet national yields remain lower than those of leading sugarcane-producing countries. Since 2009, the World Wide Fund for Nature (WWF) has provided advisory services in Jhang to improve sugarcane farming practices, particularly in integrated pest and disease management. This research study evaluated the effectiveness of WWF's advisory services in tehsil Jhang. A total of 150 farmers were randomly selected from five Learning Groups (LGs) out of 50 operating in the region. The vast majority (94.4%) reported farming as their primary income source. Farmers received guidance on controlling key sugarcane pests and diseases, including red rot, whip smut, red stripe, mosaic, root borer, termite, pyrilla, whitefly, and rats. The effectiveness of the advisory services differed across the various pest and disease management areas. The highest-rated interventions were for rat control (zinc phosphide, rated "most effective" by 73.6% of respondents, mean = 2.61), pyrilla (methamidophos, 50.4%, mean = 2.23), and whip smut (disease-free varieties, 33.6%, mean = 2.09). Moderate effectiveness was reported for mosaic and red rot control, while lower effectiveness ratings were observed for termite and root borer management. Overall, WWF's LGs played a significant role in knowledge dissemination, with most farmers applying the recommended methods. The study concludes that WWF's advisory services had a positive impact on pest and disease management in sugarcane farming, though the perceived effectiveness varied depending on the specific issue and recommended control measure. This study suggests that WWF's advisory service model can be scaled to other sugarcane-growing regions in Pakistan. Future efforts should enhance farmer training, use digital tools for pest monitoring, and tailor advice to local conditions. Strengthening feedback systems and integrating services with government and private sector efforts can improve reach, sustainability, and long-term impact on pest management and sugarcane productivity. © 2025 The Author(s)

Keywords: Disease control, Integrated Pest Management (IPM), Learning Groups (LGs), Sugarcane farming, Sustainable agriculture, WWF advisory services

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Introduction

Agriculture plays an active role in the economy of developing countries where majority population in linked directly or indirectly with it (Iqbal et al., 2018; Abbas & Shafique, 2019; Mehmood et al., 2020). No country in the world has gained economic development without emphasizing agriculture because it is primary sector of economy growth (Ahmad & Ahmad, 2018; Alamgeer et al., 2022; Dinsa & Balcha, 2024). Pakistan is basically an agricultural country (Rubab et al., 2020; Mehmood et al., 2022; Azam et al., 2023). Agriculture sector of Pakistan plays a central role in the economy as it adds 18.9 percent to GDP and absorb 42.3 percent labor force (Rehman et al., 2019; Mumtaz, 2020; Roheen et al., 2023). It is also an important source of foreign exchange and stimulates growth in other sectors (Hassan et al., 2022; Jamilah et al., 2024). It provides raw materials for local industries and also plays an important role in the development of market for industries' products (Kekere et al., 2024). Sugarcane is an essential cash crop of Pakistan (Ali et al., 2021). It is mostly cultivated for sugar and sugar related production along with an input for paper and board industry (Rasool & Arslan, 2019). Its production accounts for 3.6 percent in agriculture's value addition and 0.7 percent in overall GDP. In Pakistan, during the 2024–25 season, sugarcane was cultivated on approximately 1.193 million hectares, marking an 11.5 % increase compared to the previous year. The estimated sugarcane production reached around 85.5 million metric tons, showing a 4.3 % growth (ProPakistani, 2024). Sugarcane production increased due to increase in area sown as good economic return encouraged the growers to bring more area under cultivation and comparatively timely payments from sugar mills last year (Raza et al., 2018).

The average production of sugarcane in Pakistan is 40-45 tones/ha, while world average lies between 60-70 tones ha^{-1} (Afghan et al., 2023). Brazil is obtaining up to 90 tones ha^{-1} production of sugarcane (Greschuk et al., 2023). Due to less production of sugarcane, sugar crises raised in Pakistan with different passages of time (Afghan et al., 2023). WWF was established in 1961 in Gland, Switzerland and has been protecting the future of nature. Being a world leading organization, WWF works in 100 countries and is supported by five million members globally (Anyango-van Zwieten et al., 2019). WWF's unique way of global andbines global research with a foundation in science, involves action at every level

from local to global, and ensures the delivery of innovative solutions that meet the needs of both people and nature (Anyango van Zwieten et al., 2019). In Pakistan, WWF-Pakistan has implemented Better Management Practices (BMPs) and advisory services for sugarcane cultivation in Punjab, including extension efforts in tehsil Jhang under its Learning Group framework. Studies have documented the impact of these initiatives on biodiversity and farming practices (Khan et al., 2010). For example, Sajjad et al. (2016) assessed the influence of BMPs on farmland biodiversity associated with sugarcane crops in the region. Additionally, Ahmad et al. (2012) surveyed farmers' practices and yield responses in Jhang and Sargodha districts, providing insights into local pest and disease management approaches. WWF-Pakistan's "Pakistan Sugarcane Improvement Programme – II" was listed among its ongoing projects as of September 2016, highlighting its past commitment to sustainable sugarcane cultivation in the region (World Wide Fund for Nature [WWF] - Pakistan, 2016). However, to date there is little published research evaluating how effective these advisory services have been in influencing pest and disease management in Jhang. This study seeks to address that gap.

Sugarcane is included in water thirsty crops (Farooq & Gheewala, 2019) which consume more water than other crops growing in Pakistan. The project funded by the European Commission was launched by WWF-Pakistan for the promotion of better management practices (BMPs) for sustainable sugarcane production (WWF – Pakistan, & Eco-Conservation Initiatives, 2006). The project promoted such practices, through decreasing the amount of water and pesticides usage in sugarcane crop. The WWF-Pakistan worked closely with Agricultural extension department and other stake holders to educate the farmers for sustainable usage of agricultural resources without affecting the yield of crop (WWF – Pakistan, 2024).

To facilitate the widespread adoption of Better Management Practices (BMPs) in sugarcane farming, WWF-Pakistan, in collaboration with local stakeholders and international partners, established an enabling environment aimed at promoting sustainable agricultural practices. This framework was developed to strengthen the capacity of farmer organizations, support policy reforms by government institutions, and encourage agribusinesses to develop markets for environmentally responsible products. These coordinated efforts sought to create a sustainable ecosystem that balances agricultural productivity with conservation goals. According to Liu and Brouwer (2022), enabling environments are essential for scaling sustainable farming practices. While their analysis was broader in scope, the concept is applied here specifically in the context of WWF-Pakistan's sugarcane sustainability initiatives. The project's objectives were achieved through intensive local engagement with farming communities, combined with collaboration across stakeholders to address systemic issues beyond individual farm boundaries. BMPs were adapted to address the technical and financial limitations faced by small-scale farmers, emphasizing practical, farmer-led innovations alongside solutions developed by local agricultural research institutions. These practices were actively disseminated within the project areas to encourage widespread adoption (Liu et al., 2018). A key component of this initiative was farmer education through the formation of Learning Groups (LGs), which served as platforms for sharing knowledge and promoting the adoption of BMPs. The program also supported the integration of provincial extension services, providing long-term technical guidance to ensure sustained implementation of improved practices (Khan et al., 2021). This study was conducted to assess farmers' awareness, adoption, and the overall effectiveness of WWF-Pakistan's advisory services related to integrated pest and disease management (IPDM) in sugarcane farming. Focusing on Learning Groups (LGs) established in Tehsil Jhang, the research aims to evaluate how these services have influenced farmers' pest management practices and outcomes, and to identify opportunities for enhancing sustainable sugarcane production.

Materials and Methods

Population and sampling

This study was conducted in Tehsil Jhang, Punjab, Pakistan, where WWF-Pakistan has been actively engaged with sugarcane farmers through its Learning Groups (LGs) model. The target population consisted of approximately 1,500 sugarcane growers registered across 50 LGs, with each group comprising around 30 members. Due to logistical and financial constraints, it was not feasible to survey the entire population. Therefore, simple random sampling was employed to ensure representativeness while maintaining feasibility. A total of 5 LGs were randomly selected, yielding a sample of 150 farmers (5 LGs × 30 members). This sample size is widely considered sufficient in social and agricultural research when the population is large and relatively homogeneous. Studies recommend that a 5–15% sample, selected randomly, can provide reliable and generalizable findings under such conditions (Sanli, 2023; Hasan & Kumar, 2024). Thus, the sample was deemed appropriate for evaluating the effectiveness of WWF's advisory services in integrated pest and disease management.

Data collection

The data was collected through personal interviews with the help of pre-tested and validated interview schedule.

Preparation of interview schedule

For data collection, a comprehensive interview schedule (questionnaire) was prepared in English; however, all questions were asked in the local language, Punjabi, to ensure clarity and ease of communication. The interview schedule

comprised several sections: demographic characteristics of respondents, agronomic advisory services provided by WWF, plant protection advisory services delivered to the respondents, and recommendations for improving WWF's service delivery. Importantly, the questionnaire included specific items to assess farmers' familiarity with the identification and management of key pests, including Top borer and Stem borer. Farmers were asked whether they could recognize these pests and which control methods they employed based on advisory services received. This approach allowed the study to evaluate both the level of awareness and the adoption of pest-specific control practices promoted through WWF advisory services. The questionnaire also included questions on farmers' ability to recognize key sugarcane diseases such as red rot, whip smut, Pokkah boeng, red stripe, and mosaic. Respondents were asked whether they could identify the disease symptoms themselves or if they relied on WWF field staff for diagnosis. This helped gauge the level of disease recognition and the role of advisory services in strengthening farmers' diagnostic skills.

Pre-testing of interview schedule

To check the validity and reliability, and to remove error and omission, the interview questionnaire was pretested on 10 respondents which were not included in sample size. Some amendments were made in the light of pretesting before finalizing it.

Data analysis

The data thus collected were statistically tabulated and analyzed by working out simple percentages, means and standard deviations by using the Statistical Package for Social Sciences (SPSS). The data were then interpreted and discussed to draw conclusions and to formulate pertinent suggestions.

Results

Demographic characteristics of the respondents

Understanding the demographic profile of farmers is essential for evaluating the effectiveness of advisory services, as factors such as age, education, income source, land tenure, farm size, and social status directly influence the adoption of agricultural innovations, including Integrated Pest and Disease Management (IPDM) practices (Table 1). The age distribution revealed that 46 % of respondents were middle-aged, 31.2 % were older, and 22.4 % were younger. Age is an important variable, as it can impact a farmer's openness to learning and willingness to adopt new techniques. Middle-aged and younger farmers are often more receptive to innovation and more likely to engage with extension services, while older farmers may rely on traditional practices but bring extensive experiential knowledge. With regard to education, 37.6 % of respondents were illiterate, whereas 62.4 % had at least primary education, and 55.2 % were educated up to the matriculation level. Education plays a pivotal role in enhancing farmers' capacity to understand, evaluate, and implement improved agricultural practices. It is considered a desirable quality that contributes to the development of knowledge, wisdom, and decision-making skills. Educated farmers are generally more likely to adopt skills, methods, and techniques promoted under IPM programs. For example, a farmer with matric-level education may better understand pesticide safety instructions, pest thresholds, and timing of control measures compared to an illiterate farmer. Income source data showed that 94.4 % of respondents relied primarily on farming, while only 5.6 % reported income from other sources. This heavy dependence on agriculture makes these farmers particularly vulnerable to pest- and disease-related losses, and therefore more motivated to adopt effective pest management strategies.

In terms of land tenure, 42.2 % of the respondents were landowners, 23.2 % owner-cum-tenants, and 3.4 % tenants. Land tenure affects investment behavior and long-term decision-making. Landowners are generally more willing to invest in sustainable practices such as IPDM, whereas tenants may be constrained by short-term leases or limited autonomy over land-use decisions. Farm size analysis revealed that 80.8 % of farmers had small landholdings (up to 12.5 acres), and 93.6 % cultivated sugarcane on this limited acreage. These figures are consistent with national trends and highlight the smallholder nature of sugarcane farming in the region. Small farmers often face resource constraints that limit their access to inputs and training, making advisory support crucial for productivity and sustainability. Regarding social status, 96 % of respondents identified as ordinary farmers registered with WWF, while only a small fraction held local leadership positions such as *Nazim* (local government head), Councilor, or *Namberdar* (village-level revenue or community representative). Social status can influence access to information networks and influence within the community, potentially affecting the dissemination and credibility of advisory messages. Lastly, annual income data showed that 33.6 % of farmers earned less than Rs. 50,000, 51.2 % earned between Rs. 50,000–100,000, and only 15.2 % earned above Rs. 100,000. This indicates that the majority of respondents operate at subsistence or near-subsistence levels, reinforcing the need for cost-effective and targeted interventions like those provided by WWF.

Effectiveness of advisory services for Root borer and Gurdaspur borer control

According to Table 2, LGs mainly provided information on resistant cultivars (72.8 %), crop rotation (67.2 %), hand picking (76 %), and hoeing (79.2 %). Effectiveness ratings varied: hand picking and Trichocards (43.2 % rated most

effective) were rated more favorably, while resistant cultivars and crop rotation were viewed as less effective. Biological controls, such as bio-agents and sex pheromones, were met with varied perceptions of effectiveness among farmers. Mechanical methods like light traps and rope dragging were less commonly used and rated lower in effectiveness. Table 2 shows that LGs commonly advised resistant cultivars (75.2 %), crop rotation (71.2 %), hand picking (75.2 %), and hoeing (76.8 %). Trichocards, which are biological control tools containing eggs of *Trichogramma* spp., were rated as 'most effective' by 44% of respondents for managing borer pests. However, hand picking and mechanical methods like light traps and rope dragging had lower effectiveness ratings. Overall, Trichocards were perceived as the most effective, while cultural and mechanical methods had mixed effectiveness according to farmer feedback.

Table 1 Selected demographic and socio-economic characteristics of the respondents

Selected characteristics	Frequency	Percentage
Age		
Young (up to 25)	28	22.4
Middle age (26-40)	58	46.4
Old (above 40)	39	31.2
Educational level		
Illiterate	47	37.6
Up to primary	3	2.4
Up to matric	69	55.2
Above matric	6	4.8
Profession		
Literate	118	94.4
Illiterate	4	3.2
Other sources	3	2.4
Tenureship		
Tenant	43	34.4
Owner	53	42.4
Owner-cum-tenant	29	23.2
Size of landholding (acres)		
Up to 12.5	101	80.8
12.5-25	15	12.8
>25	9	7.2
Land area under sugarcane crop		
Small (up to 12.5 acres)	117	93.6
Medium (12.5-25 acres)	3	2.4
Large (above 25 acres)	5	4.0
Social status		
Ordinary farmer	120	96.0
Councilor	2	1.6
Nazim	1	0.8
Namberdar	1	0.8
Chairman zakat and usher committee	1	0.8
Annual income (PKR)		
Up to 50,000	42	33.6
50,000 to 100,000	64	51.2
Above 100,000	19	5.2

Effectiveness of advisory services for Top borer and Stem borer control

The majority of respondents received advisory services from WWF's Local Groups (LGs) on various top borer control methods. Hand picking was advised to 57.6 % of respondents, but it was rated least effective by 48.8 %, with a low mean score of 1.27 (SD = 0.81) (Table 3). Similarly, crop rotation (78.4 % advised) and hoeing (67.2 %) were commonly recommended but also mostly rated as least effective (52 % and 24.8 %, respectively). Resistant cultivars (recommended to 78.4 %) were better received, with 28 % rating the advice as effective and 20.8 % as most effective (mean = 1.48). Biological methods such as Trichocards (76 %)

and sex pheromones (51.2 %) were perceived as more effective, with Trichocards receiving the highest mean score of 1.64. Mechanical methods like light traps (82.4 %) showed mixed results, with similar proportions rating them as effective (36 %) and least effective (35.2 %). Rope dragging, though less promoted (38.4 %), was mostly rated as least effective (24 %) (Table 3). Advisory services for stem borer control followed a similar pattern. Hand picking (63.2 %) and crop rotation (82.4 %) were frequently advised but received moderate effectiveness ratings, with both methods rated least effective by around 45 % of respondents. Resistant cultivars (82.4 %) were more positively perceived, with 28 % rating them as most effective (mean = 1.65) (Table 3). Hoeing (76.8 %) had mixed responses, with equal proportions (32.8 %) rating it as the most and least effective. Trichocards (85.6 %) were among the most widely recommended biological methods and received relatively high effectiveness ratings (mean = 1.65). Sex pheromones (56 %) and bio-agents (27.2 %) were less promoted and had lower perceived effectiveness. Mechanical controls such as light traps (62.4 %) and rope dragging (53.6 %) were mostly rated as least effective (44.8 % and 36 %, respectively).

Effectiveness of advisory services for Termite and Pyrilla control

The effectiveness of advisory services provided by the Local Groups (LGs) of WWF for termite and Pyrilla control was assessed based on respondents' feedback (Table 4). For termite control, cultural methods such as hand picking were the most recommended (60.8 %) but were generally rated as least effective by 41.6 % of respondents, with a low mean effectiveness score of 1.40. Crop rotation (68.8 %) and resistant cultivars (75.2 %) were also advised, with resistant cultivars receiving a relatively better response, 33.6 % rated it most effective (mean: 1.59) (Table 4). Hoeing (62.4 %) was considered moderately effective (mean: 1.06). Biological methods like Trichocards were provided to 79.2 % of farmers and received mixed reviews; 32.8 % rated it least effective and 32 % the most effective (mean: 1.57). Bio agents and sex pheromones, though less commonly recommended, were generally perceived as ineffective or only marginally effective, with mean scores of 1.51 and 1.97, respectively. Mechanical approaches such as light traps (44.8 %) and rope dragging (73.6 %) were mostly rated as least effective, especially rope dragging with a mean of 1.16 (Table 4). In contrast, chemical methods showed the highest effectiveness. Chlorpyrifos 40EC, recommended to all respondents, had a mean score of 2.05, while Fipronil 50EC was used by 78.4 % and rated moderately effective (mean: 1.57). For Pyrilla control, cultural practices like hand picking (64 %) and crop rotation (75.2 %) received mixed responses. Resistant cultivars were better rated, with 40.8 % considering them most effective (mean: 1.76), while hoeing, practiced by 84 % of respondents, was rated highly effective (mean: 1.16) (Table 4). Among biological methods, Trichocards (85.6 %) were considered most effective by 54.4 % of respondents (mean: 2.08), while bio agents and sex pheromones received lower effectiveness ratings (means: 1.77 and 2.07). Mechanical methods such as light traps (57.6 %) were moderately well received (mean: 1.95), whereas rope dragging (48.8 %) was mostly rated as ineffective (mean: 1.12). Chemical control methods proved to be the most effective; Methamidophos, recommended to all respondents, had the highest mean effectiveness score (2.23), with 50.4 % rating it most effective. Similarly, Monocrotophos, provided to 77.6 %, also received a high effectiveness rating (mean: 2.23) (Table 4).

Effectiveness of advisory services for White fly and Rats control

Among cultural methods, hand picking was the most widely promoted (88.8 % of respondents), yet it was considered only moderately effective (mean = 1.70). Crop rotation (84 %) and resistant cultivars (60.8 %) were also common, though their effectiveness was rated lower (means = 1.59 and 1.46, respectively). Hoeing had a relatively balanced effectiveness rating (mean = 1.31), with a large proportion finding it moderately helpful (Table 5). Biological methods like the use of Trichocards (83.2 %) stood out as the most effective (mean = 1.88), with 42.2 % of respondents rating it as "most effective." In contrast, bio agents (57.6 %) and sex pheromones (58.4 %) received lower effectiveness ratings (means = 1.51 and 1.04 respectively), indicating mixed perceptions or possible implementation issues (Table 5). Mechanical interventions such as light traps and rope dragging were less widely used (55.2 % and 56.8 %) and were generally rated as ineffective to moderately effective (means = 1.63 and 1.42) (Table 5). Chemical control using Endosulfan (1 liter $acre^{-1}$) was adopted by 74.4 % of respondents and was considered one of the more effective methods (mean = 1.86), with over 43 % rating it "the most effective" (Table 5). For rat control, earthing up (63.2 %) was the most promoted cultural method and was rated as moderately effective (mean = 1.15), with 40.8 % considering it effective. Rat killing agents had limited reach (36 %) and were rated poorly (mean = 1.48), suggesting either low efficacy or inadequate guidance (Table 5). Traps were used by 68 % of farmers but were mostly seen as ineffective (mean = 1.37), with nearly half (46.4 %) rating them as least effective (Table 5). Chemical control proved to be the most successful strategy. Zinc phosphide was universally provided (100 % of respondents), with 73.6 % rating it "most effective" and a high mean effectiveness score of 2.61. Similarly, Claret (86.4 %) was also well received, with a mean score of 2.08 (Table 5).

Table 2 Distribution of respondents regarding advisory services rendered to them by WWF for the control of Root borer and Gurdaspur borer of sugarcane

Advisory services	Response				Effectiveness						Mean	S.D.
	Yes		No		Least Effective		Effective		Most Effective			
Root borer	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%		
Cultural method												
Resistant cultivars	91	72.8	34	27.2	34	27.2	32	25.6	25	20	1.38	1.09
Crop rotation	84	67.2	41	32.8	28	22.4	42	33.6	14	11.2	1.23	1.03
Hand picking	95	76	30	24	9	7.2	60	48	26	20.8	1.65	1.06
Hoeing	99	79.2	26	20.8	43	34.4	40	32	16	12.8	1.2	0.4
Biological method												
Bio agents (insects, pathogens)	62	49.6	63	50.4	29	23.2	11	8.8	22	17.6	2.06	1.14
Trichocards 10 cards acre^{-1}	92	73.6	33	26.4	8	6.4	30	24	54	43.2	1.84	1.24
Sex pheromones	91	72.8	34	27.2	31	24.8	44	35.2	16	12.8	1.33	1.01
Mechanical method												
Light traps	69	55.2	56	44.8	29	23.2	32	25.6	8	6.4	1.69	0.98
Rope dragging	80	64	45	36	55	44	16	12.8	9	7.2	1.42	0.88
Gurdaspur borer												
Cultural method												
Resistant cultivars	94	75.2	31	24.8	29	23.2	24	19.2	41	32.8	1.6	1.18
Crop rotation	89	71.2	36	28.8	11	8.8	55	44	23	18.4	1.52	1.09
Hand picking	94	75.2	31	24.8	61	48.8	17	13.6	16	12.8	1.14	0.93
Hoeing	96	76.8	29	23.2	39	31.2	21	16.8	36	28.8	1.51	1.14
Biological method												
Sex Pheromones	67	53.6	58	46.4	12	9.6	36	28.8	19	15.2	1.12	1.16
Trichocards 10 cards acre^{-1}	104	83.2	21	16.8	30	24	19	15.2	55	44	1.86	1.15
Mechanical method												
Light traps	41	32.8	84	67.2	26	20.8	10	8	5	4	1.48	0.8
Rope dragging	66	52.8	59	47.2	30	24	24	19.2	12	9.6	1.72	1.02

Scale: 1= Least effective, 2= Effective, 3 = Most effective; S.D. = Standard deviation; Freq. = Frequency; % = Percentage

Table 3 Distribution of respondents regarding advisory services rendered to them by WWF for the control of Top borer and Stem borer of sugarcane

Advisory services	Response				Effectiveness						Mean	S.D.
	Yes		No		Least Effective		Effective		Most Effective			
Top borer	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**		
Cultural method												
Resistant cultivars	72	57.6	53	42.4	61	48.8	2	1.6	9	7.2	1.27	0.81
Crop rotation	98	78.4	27	21.6	37	29.6	35	28	26	20.8	1.48	1.05
Hand picking	91	72.8	34	27.2	65	52	14	11.2	12	9.6	1.03	0.87
Hoeing	84	67.2	41	32.8	31	24.8	27	21.6	26	20.8	1.3	1.13
Biological method												
Bio agents (insects, pathogens)	59	47.2	66	52.8	35	28	15	12	9	7.2	1.55	0.93
Sex pheromones	64	51.2	61	48.8	10	8	40	32	14	11.2	1.05	1.12
Trichocards 10 cares acre^{-1}	95	76	30	24	26	20.8	27	21.6	42	33.7	1.64	1.17
Mechanical method												
Light traps	103	82.4	22	17.6	44	35.2	45	36	14	11.2	1.4	0.9
Rope dragging	48	38.4	77	61.6	30	24	9	7.2	9	7.2	1.56	0.9
Stem borer												
Cultural method												
Resistant cultivars	79	63.2	46	36.8	57	45	15	12	7	5.6	1.36	0.83
Crop rotation	103	82.4	22	17.6	34	27.2	34	27.2	35	28	1.65	1.07
Hand picking	100	80	25	20	53	42.4	24	19.2	23	18.4	1.36	1
Hoeing	96	76.8	29	23.2	41	32.8	14	11.2	41	32.8	1.53	1.17
Biological method												
Bio agents (insects, pathogens)	34	27.2	91	72.8	15	12	9	7.2	10	8	1.85	0.93
Trichocards 10 cards acre^{-1}	107	85.6	18	14.4	34	27.2	46	36.8	27	21.6	1.65	0.97
Sex pheromones	70	56	55	44	24	19.2	28	22.4	18	14.4	1.07	1.11
Mechanical method												
Light traps	78	62.4	47	37.6	56	44.8	14	11.2	8	6.4	1.38	0.85
Rope dragging	67	53.6	58	46.4	45	36	12	9.6	10	8	1.47	0.91

Scale: 1= Least effective, 2= Effective, 3 = Most effective; S.D. = Standard deviation; Freq. = Frequency; % = Percentage

Advisory services rendered by WWF to control diseases in sugarcane

The advisory services provided by WWF's Local Groups (LGs) played a significant role in helping farmers manage sugarcane diseases through cultural and chemical methods (Table 6). For red rot control, 66.4 % of respondents reported receiving guidance on using resistant cultivars, with 27.2 % rating this information as the most effective. Crop rotation was suggested to 70.4 % of respondents, and 39.2 % found it effective. Information on disease-free varieties was received by 60.8 % of farmers, with 24.4 % rating it effective and 22.4 % as most effective. Meanwhile, 56.8 % of farmers received advisory guidance on using Topsin M (50ml/acre), but 26.4 % rated this advisory as least effective. For whip smut, 86.4 % of respondents were advised to use resistant cultivars, and 58.4 % considered this effective. Disease-free varieties were recommended to 92.2 %, with a high effectiveness rating of 50.4 %. Crop rotation was suggested to 88 %, and 43.2 % found it the most effective. About 84 % received advice on using Topsin M, rated effective by 52 %. In managing Pokka boeng, 82.4 % received guidance on resistant cultivars, with 56.8 % considering it most effective. Disease-free varieties were suggested to 88.8 % of respondents, with over half (52 %) rating them effective. Crop rotation was advised to 87.2 % and 41.6 % rated it effective. Topsin M (80 %) was also promoted, with effectiveness rating of 35.2 %. For red stripe, resistant cultivars were recommended to 86.4 % of respondents, with 37.6 % finding them effective and 32 % most effective. Disease-free varieties were advised to 79.2 %, rated effective by 40.8 %. Crop rotation was suggested to 75.2 %, with 39.2 % rating it effective. Use of Topsin M was lower (63.2 %) and largely deemed least effective (28 %). Regarding mosaic disease, 76.8 % received information on resistant cultivars, and more than half (51.2 %) found it the most effective. Disease-free varieties were recommended to 72 %, and crop rotation to 83.2 %, with effectiveness ratings of 36.8 % and 52 %, respectively. Use of Topsin M (90.4 %) was rated effective by 64.4 % of respondents.

Usefulness of WWF advisory services in Sugarcane cultivation

The advisory services provided by WWF in sugarcane cultivation were perceived as largely useful by respondents across various areas of plant production and protection (Table 7). In land preparation, 60 % of farmers rated the advisory services as high to very high in usefulness (mean = 3.73, SD = 0.87), with ploughing (mean = 3.85, SD = 0.82) and especially planking (mean = 4.09, SD = 0.72) receiving the highest ratings (Table 7). Moderate perceptions were noted in guidance related to sowing, with the time of sowing (mean = 3.31, SD = 0.83), method (mean = 3.38, SD = 0.84), and seed rate (mean = 3.29, SD = 0.83) reflecting a balanced distribution across medium and high ratings. However, irrigation received the lowest mean score among production practices (mean = 2.99, SD = 0.92), indicating relatively limited perceived effectiveness. In terms of input use, services related to FYM/chemical fertilizers (mean = 3.43, SD = 0.90) and varietal recommendations (mean = 3.35, SD = 0.88) were moderately well-received, while seed treatment (mean = 2.70, SD = 0.98) was rated the least useful (Table 7). Earthing-up services were better appreciated (mean = 3.69, SD = 0.86). Overall, the average usefulness rating for plant production services was 3.43 (SD = 0.85). For plant protection, services related to chemical control (mean = 3.53, SD = 0.96) and cultural methods (mean = 3.50, SD = 0.94) were rated most useful, followed by pest management (mean = 3.30, SD = 1.00), weed control (mean = 3.33, SD = 0.94), and biological methods (mean = 3.28, SD = 1.07). Mechanical methods received the lowest score (mean = 2.96, SD = 1.12), indicating lower effectiveness. The overall mean usefulness for plant protection services was 3.29 (SD = 1.01), reflecting a moderate level of satisfaction among farmers (Table 7).

Discussion

The active role of civil society organizations and support programs in addressing environmental and agricultural challenges reflects a broader trend toward inclusive and participatory policymaking (Rusfiana & Kurniasih, 2024). As environmental concerns and rural development pressures grow more complex, non-state actors particularly non-governmental organizations (NGOs) have emerged as key players in bridging the gap between grassroots realities and policy-level decisions (Luqman et al., 2021). Their interventions not only influence how resources are managed but also reshape governance frameworks through advocacy, technical input, and collaboration (Cordery et al., 2023). The Learning Groups (LGs) established by WWF not only facilitated the dissemination of technical advice but also built social capital among farmers, enabling more widespread adoption of sustainable practices. However, as noted by Oberthur (2003), stronger institutional collaboration is still needed. Integrating WWF's efforts with government extension services, NARES, and private sector actors could significantly enhance the scale and sustainability of advisory programs.

Table 4 Distribution of respondents regarding advisory services rendered to them by WWF for the control of Termite and Pyrilla of sugarcane

Advisory services	Response				Effectiveness						Mean	S.D.
	Yes		No		Least Effective		Effective		Most Effective			
Termite	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**		
Cultural method												
Resistant cultivars	76	60.8	49	39.2	52	41.6	17	13.6	7	5.6	1.4	0.85
Crop rotation	94	75.2	31	24.8	31	24.8	21	16.8	42	33.6	1.59	1.19
Hand picking	86	68.8	39	31.2	36	28.8	21	16.8	29	23.2	1.32	1.14
Hoeing	78	62.4	47	37.6	33	26.4	35	28	10	8	1.06	0.98
Biological method												
Bio agents (insects, pathogens)	58	64.4	67	53.6	38	30.4	10	8	10	8	1.51	0.92
Trichocards 10 cards acre^{-1}	99	79.2	26	20.8	41	32.8	18	14.4	40	32	1.57	1.14
Sex pheromones	39	31.2	86	68.8	10	8	20	16	9	7.2	1.97	0.99
Mechanical method												
Light traps	56	44.8	69	55.2	37	29.6	12	9.6	7	5.6	1.46	0.87
Rope dragging	92	73.6	33	26.4	48	38.4	34	27.2	10	8	1.16	0.91
Chemical method												
Chlorpyrifos 40EC 1 liter acre^{-1}	125	100	0	0	36	28.8	46	36.8	43	34.4	2.05	0.79
Fipronil 50EC 2 liter acre^{-1}	98	78.4	27	21.6	35	28	27	21.6	36	28.8	1.57	1.12
Pyrilla												
Cultural method												
Resistant cultivars	80	64	45	36	50	40	20	16	10	8	1.25	0.91
Crop rotation	94	75.2	31	24.8	18	14.4	25	20	51	41	1.76	1.22
Hand picking	100	80	25	20	31	24.8	37	29.6	32	26	1.6	1.07
Hoeing	105	84	20	16	44	35.2	55	44	6	4.8	1.16	0.36
Biological method												
Bio agents (insects, pathogens)	40	32	85	68	20	16	9	7.2	11	8.8	1.77	0.96
Trichocards 10 cards acre^{-1}	107	85.6	18	14.4	22	17.6	17	13.6	68	54	2.08	1.14
Sex pheromones	48	38.4	77	61.6	29	23.2	10	8	9	7.2	2.07	1.15
Mechanical method												
Light traps	72	57.6	53	42.4	12	9.6	51	40.8	9	7.2	1.95	0.91
Rope dragging	91	48.8	64	51.2	49	39.2	7	5.6	5	4	1.12	1.05
Chemical method												
Methamidophos 1.5 liter acre^{-1}	125	100	0	0	34	27.2	28	22.4	63	50	2.23	0.76
Monocrotophos 1.0 liter acre^{-1}	97	77.6	28	22.4	19	15.2	66	52.8	12	9.6	2.23	0.85

Scale: 1= Least effective, 2= Effective, 3 = Most effective; S.D. = Standard deviation; Freq. = Frequency; % = Percentage

Table 5 Distribution of respondents regarding advisory services rendered to them by WWF for the control of White fly and Rats of sugarcane

Advisory services	Response				Effectiveness						Mean	S.D.
	Yes		No		Least Effective		Effective		Most Effective			
Termite	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%		
Cultural method												
Resistant cultivars	76	60.8	49	39.2	50	40	17	13.6	9	7.2	1.46	0.89
Crop rotation	105	84	20	16	45	36	26	20.8	34	27	1.59	1.05
Hand picking	111	88.8	14	11.2	47	37.6	26	20.8	38	30	1.7	1.02
Hoeing	96	76.8	29	23.2	39	31.2	46	36.8	11	8.8	1.31	0.92
Biological method												
Bio agents (insects, pathogens)	72	57.6	53	42.4	47	37.6	13	10.4	12	9.6	1.51	0.95
Sex pheromones	73	58.4	52	41.6	35	28	18	14.4	20	16	1.04	1.09
Trichocards 10 cards acre^{-1}	104	83.2	21	16.8	26	20.8	25	20	53	42	1.88	1.14
Mechanical method												
Light traps	69	55.2	56	44.8	40	32	14	11.2	15	12	1.63	1.01
Rope dragging	71	56.8	54	43.2	48	38.4	16	12.8	7	5.6	1.42	0.86
Chemical method												
Endosulfan 1 litre acre^{-1}	93	74.4	32	25.6	7	5.6	32	25.6	54	43	1.86	1.22
Rats												
Cultural method												
Earthing up	79	63.2	46	36.8	21	16.8	51	40.8	7	5.6	1.15	0.9
Biological method												
Rat killing agents	45	36	80	64	29	23.2	10	8	6	4.8	1.48	0.83
Mechanical method												
Traps	85	68	40	32	58	46.4	22	17.6	5	4	1.37	0.81
Chemical method												
Zinc phosphide 0.5 kg acre^{-1}	125	100	0	0	15	12	18	14.4	92	73.6	2.61	0.69
Claret 1.0 packet acre^{-1}	108	86.4	17	13.6	16	12.8	31	24.8	61	48.8	2.08	1.07

Scale: 1= Least effective, 2= Effective, 3 = Most effective; S.D. = Standard deviation; Freq. = Frequency; % = Percentage

Within this context, Weber et al. (2000) emphasized that environmental NGOs in Germany have long been engaged in forest policy discourse. Organizations such as Greenpeace, Robin Wood, WWF, and Deutschland are not confined to traditional roles of forest development, protection, or sustainable management. Instead, they adopt a proactive stance through various direct-action strategies such as email campaigns, public demonstrations, and policy advocacy to encourage both forest owners and political decision-makers to embrace sustainability in forest management. A similar type of study was conducted by Mustafa (2001) who highlighted the significant difficulties faced by farmers, including disease outbreaks, rising costs of inputs, unpredictable weather patterns, and lack of irrigation facilities. The National Rural Support Program (NRSP) was instrumental in helping many farmers overcome these challenges. Importantly, a majority of the respondents were aware of and participated in agricultural training programs offered by NRSP's scientific officers. This emphasizes the value of targeted support initiatives and the critical role of capacity building in strengthening the resilience of rural communities.

The findings of Prajapati et al. (2025) emphasized the importance of participatory approaches, local knowledge, and farmer-to-farmer engagement in building agricultural resilience principles that also resonate with the current study on sugarcane farming in Jhang, Pakistan. Similar to the role of Movimiento Campesino a Campesino (MCAC) in Nicaragua, the WWF's Learning Groups (LGs) served as key platforms for disseminating knowledge and promoting sustainable practices among sugarcane farmers. Just as Nicaraguan farmers contributed to the monitoring and development of sustainable land management systems, sugarcane farmers in Jhang actively applied pest and disease control methods advised by WWF. This similar study highlights how community-based advisory models, backed by NGO support, can enhance local capacity and agricultural sustainability in diverse contexts. Therefore, integrating farmer-led initiatives with institutional support as seen in both Nicaragua and Jhang, can serve as a framework for promoting resilience and long-term sustainability in agriculture, particularly in the face of climate challenges and pest pressures.

In the present study, farmers rated WWF's advisory services as generally effective, particularly in areas such as ploughing, planking, and chemical pest control. However, lower ratings for irrigation (mean = 2.99) and seed treatment (mean = 2.70) indicate certain gaps in advisory coverage. These findings align with Dastgeer's (2003) analysis of the AKRSP model, which emphasized the importance of targeted extension support, improved productivity, and investment in rural human capital. Likewise, Zubair et al. (2022) highlighted the potential of NGOs and National Agricultural Research and Extension Systems (NARES) to stabilize rural livelihoods but also pointed out weaknesses in inter-institutional coordination. The moderate effectiveness reported in our findings suggests that while WWF is playing a critical advisory role, a lack of synergy with other institutional actors may be limiting the overall impact. This supports the need for a more integrated approach to Agricultural Technical Development (ATD), as effective collaboration could enhance both the reach and quality of extension services.

The findings of this study reveal a positive and significant impact of World Wide Fund (WWF) advisory services on the implementation of integrated pest and disease management (IPM) practices in sugarcane farming in district Jhang. Farmers who adopted WWF's guidance demonstrated increased awareness and practical application of environmentally friendly pest control measures, including reduced reliance on synthetic pesticides, adoption of need-based interventions, and use of mechanical and botanical control methods. This shift not only contributed to more sustainable pest management but also led to reported improvements in crop health and yield quality, reduced production costs, and enhanced farmer knowledge. These findings align closely with those of Sajjad et al. (2016), who evaluated the impact of Better Management Practices (BMPs) in sugarcane fields and found that sustained application of such practices led to increased biodiversity and improved ecosystem functions.

The findings of this study demonstrate the positive impact of WWF's advisory services on integrated pest and disease management (IPM) practices among sugarcane farmers in Jhang, Pakistan. The targeted, need-based guidance provided by WWF enabled farmers to reduce reliance on synthetic pesticides, adopt environmentally friendly methods, and improve crop health and productivity. Similarly, Abbas et al. (2020) in Punjab, who compared the effectiveness of public and private agricultural advisory services. Their research highlights that while private sector extension staff had more frequent contact with farmers and was perceived as more effective in advisory services related to crop management, the public sector excelled in advising on the safe use of pesticides. Both studies emphasize the critical role of accessible, timely, and quality advisory services in enhancing farmers' knowledge and promoting sustainable agricultural practices. Moreover, they collectively indicate the necessity for strengthening public extension systems through institutional reforms, capacity building, and improved farmer engagement to complement private and NGO-led initiatives like those of WWF. Ultimately, integrated efforts across public, private, and non-governmental sectors can synergistically support sustainable sugarcane production, better pest management, and improved socio-economic outcomes for farmers.

Table 6 Distribution of respondents regarding advisory services rendered to them by WWF for for controlling various diseases of sugarcane

Advisory services	**Response**				**Effectiveness**							
Cultural/chemical method for controlling	**Yes**		**No**		**Least Effective**		**Effective**		**Most Effective**		**Mean**	**S.D.**
Red rot	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**		
Resistant cultivators	83	66.4	42	33.6	22	17.6	27	21.6	34	27.2	1.42	1.21
Crop rotation	88	70.4	37	88	20	16	49	39.2	19	15.2	1.4	1.07
Topsin M 50 ml acre^{-1}	71	56.8	54	43.2	33	26.4	23	18.4	15	12	1.74	1.05
Cultural/chemical method for controlling Whip smut												
Resistant cultivators	108	86.4	17	13.6	11	8.8	73	58.4	24	19.2	1.83	0.89
Crop rotation	115	92.2	10	8	10	8	63	50.4	42	33.6	2.09	0.85
Topsin M 50 ml acre^{-1}	105	84	20	16	23	18.4	65	52	17	13.6	1.63	0.91
Cultural/chemical method for controlling Pokka boeng												
Resistant cultivators	103	82.4	22	17.6	11	8.8	21	16.8	71	56.8	2.12	1.61
Crop rotation	111	88.8	14	11.2	25	20	65	52	21	16.8	1.74	0.86
Topsin M 50 ml acre^{-1}	100	80	25	20	27	21.6	53	42.4	20	16	1.54	0.98
Cultural/chemical method for controlling Red stripe												
Resistant cultivators	108	86.4	17	13.6	21	16.8	47	37.6	40	32	1.88	1.01
Crop rotation	99	79.2	26	20.8	32	25.6	51	40.8	16	12.8	1.45	0.96
Topsin M 50 ml acre^{-1}	79	63.2	46	36.8	35	28	23	18.4	21	16.8	1.15	1.1
Cultural/chemical method for controlling Mosaic												
Resistant cultivators	96	76.8	29	23.2	21	16.8	11	8.8	64	51.2	1.88	1.26
Crop rotation	90	72	35	28	20	16	46	36.8	24	19.2	1.47	1.09
Topsin M 50 ml acre^{-1}	113	90.4	12	9.6	19	15.2	81	64.4	13	10.4	1.76	0.76

Scale: 1= Least effective, 2= Effective, 3 = Most effective; S.D. = Standard deviation; Freq. = Frequency; % = Percentage

Table 7 Distribution of respondents regarding the extent of usefulness of advisory services rendered to them by WWF

Advisory services	**Extent of usefulness**										**Mean**	**S.D.**
	Very Low (1)		**Low (2)**		**Medium (3)**		**High (4)**		**Very High (5)**			
Plant production advisory services	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**		
Land preparation	0	0	9	7.2	41	32.8	49	39.2	26	20.8	3.73	0.87
Ploughing	0	0	5	4	37	29.6	54	43.2	29	23.2	3.85	0.82
Planking	0	0	0	0	27	21.6	59	47.2	39	31.2	4.09	0.72
Time of sowing	0	0	22	17.6	50	40	45	36	8	6.4	3.31	0.83
Method of sowing	0	0	19	15.2	50	40	45	36	11	8.8	3.38	0.84
Seed rate	0	0	21	16.8	55	44	40	32	9	7.2	3.29	0.83
Irrigation	4	3.2	35	28	51	40	28	22.4	7	5.6	2.99	0.92
FYM/Chemical fertilizers	0	0	20	16	46	36.8	44	35.2	15	12	3.43	0.9
Varieties	0	0	22	17.6	49	39.2	42	33.6	12	9.6	3.35	0.88
Seed treatment	12	9.6	43	34.4	45	36	20	16	5	4	2.7	0.98
Earthing up	0	0	10	8	41	32	51	40.8	23	18.4	3.69	0.86
Overall											3.43	0.85
Plant protection advisory services												
Weeds	3	2.4	20	16	46	36.8	44	35.2	12	9.6	3.33	0.94
Diseases	6	4.8	27	21.6	43	34.4	36	28.8	13	10.4	3.18	1.04
Insects/pests	4	3.2	23	18.4	44	35.2	39	31.2	15	12	3.3	1
Cultural method	2	1.6	15	12	45	36	44	35.2	19	15.2	3.5	0.94
Mechanical method	9	7.2	38	30.4	41	32.8	22	17.6	15	12	2.96	1.12
Biological method	7	5.6	22	17.6	40	32	40	32	16	12.8	3.28	1.07
Chemical method	1	0.8	18	14.4	40	32	45	36	21	16.8	3.53	0.96
Overall											**3.29**	**1.01**

Scale: 1= Least effective, 2= Effective, 3 = Most effective; S.D. = Standard deviation; Freq. = Frequency; % = Percentage

Our findings also align closely with the findings of Khan et al. (2024), who explored farmers' perceptions regarding the use of Trichogramma as a biological control agent against sugarcane pests in the same region. They found that despite farmers' willingness to adopt new pest management technologies, there was a significant knowledge gap, especially among less educated and small-scale farmers, regarding the proper use and application timing of Trichogramma. This gap in awareness and training parallels challenges faced in implementing effective IPM strategies, as highlighted in our study, where continuous advisory support was key in overcoming initial resistance and knowledge barriers. Both studies emphasize the critical role of advisory services and training programs in bridging knowledge gaps and encouraging adoption of biological pest control methods. Moreover, the findings suggest that the success of biological control initiatives, like Trichogramma deployment, heavily depends on well-structured extension and advisory frameworks such as those provided by WWF, which offer consistent technical guidance and capacity building. Therefore, integrating biological control agents into IPM packages supported by strong advisory services can significantly enhance pest management efficiency, reduce pesticide dependency, and improve sugarcane productivity in the region.

Conclusion and Recommendations

The findings of this study indicate that approximately 63% of the participants were literate, and a vast majority (95%) identified farming as their primary source of income. The Learning Groups (LGs) established by the World Wide Fund for Nature (WWF) played a key role in providing advisory services to sugarcane growers, particularly in areas related to plant protection measures such as cultural, mechanical, biological, and chemical control methods. Farmers generally rated the information provided by WWF as falling between "least effective" and "effective," with the overall mean scores for plant production and plant protection advisory services being 3.43 and 3.29, respectively. The standard deviations of 0.85 and 1.01 suggest some variation in perceptions, but on average, the advisory services were rated as moderately to highly effective. These findings reflect a positive impact of WWF's advisory efforts, though there remains room for improvement in tailoring services to farmer needs. Given the diversity in farmers' skills, experience, and levels of understanding, WWF's advisory services should be further refined to align more closely with the local context especially the knowledge, attitudes, and practices of the farming community. Field extension staff should place greater emphasis on promoting Integrated Pest Management (IPM) techniques, which offer sustainable and cost-effective alternatives for pest and disease control in sugarcane cultivation. Based on the study's results, it is recommended that the Better Management Practices (BMPs) demonstrated through WWF's Learning Groups be scaled up and extended across other sugarcane-growing regions in Punjab. Enhancing farmer training, integrating digital advisory tools, and building stronger links with government and private sector extension systems will further improve the reach, effectiveness, and long-term sustainability of WWF's advisory model.

Declarations

i. Ethics approval and consent to participate

This study did not require formal ethical approval from an institutional review board, as per the policies of the researchers' affiliated institutions. However, all ethical considerations for social research involving human participants were carefully followed. Informed consent was obtained from all participating farmers prior to data collection. Participation was entirely voluntary, and confidentiality and anonymity of responses were ensured.

ii. Consent for publication

Consent for publication is not applicable, as the study does not include any identifying information or personal data of individual participants.

iii. Data availability

All data generated or analyzed during this study are included in this article.

iv. Competing interests

Authors have declared that no competing interests exist.

v. Authors' contributions

The author was solely responsible for all aspects of the research and manuscript preparation.

vi. Funding

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vii. Acknowledgement

Not applicable.

viii. SDGs addressed

Zero Hunger, Responsible Consumption and Production, Life on Land

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